

SOME FACTORS IN THE EPIDEMIOLOGY OF POLIOMYELITIS

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Notwithstanding the brilliant work of the last three years upon the experimental transmission of poliomyelitis, and the numerous painstaking epidemiologic studies of the disease, there remains, in the minds of practically all who have studied the subject, considerable doubt as to the means by which this infection is actually disseminated in nature. The explanation of this uncertainty is to be found, not in the incompleteness of the experimental work, nor altogether in the paucity of epidemiologic data, but rather in the seeming lack of harmony between experimental results and epidemiologic observations.

Experimentally it has been shown that poliomyelitis is an infectious disease, due to a filterable virus, easily, almost constantly transmissible to monkeys. It has quite recently been shown that the virus which is the specific infective agent may be present in the discharges from the naso-pharynx, the trachea and the intestines of persons suffering from poliomyelitis. It has also been shown that monkeys may, though not constantly, be infected through the nasal mucous membrane, and under somewhat artificial conditions, through the mucous membrane of the gastro-intestinal tract.

Lower animals other than the monkey have not been found susceptible to laboratory infection with poliomyelitis, with the exception of the rabbit, in which an atypical form of the infection may occasionally be produced.

The virus of poliomyelitis has been found, in nature, only in the organs and discharges of persons suffering with or recently dead of the disease.* To this statement there is one exception, namely, the finding of the virus in the dust of a room occupied by a patient suffering with poliomyelitis. The dust was presumably contaminated with the discharges from the patient and attendants.

The experiments showing the infectiousness of the discharges from patients and the possibility of infection taking place through mucous membranes not grossly injured, form a very convincing chain of evidence, if not actual proof that the disease is, in nature, transmissible directly from person to person.

The doubt as to whether this is the real means of transmission in nature

*See note at conclusion.

has arisen because of the fact that even in epidemics poliomyelitis does not usually exhibit the characteristics which we are accustomed to attribute to contagious diseases.

Making due allowance for rather numerous exceptions, the well-established epidemiologic characteristics of poliomyelitis are the following:

1. It has, both in epidemic and sporadic form, an extremely wide, not definitely defined geographic distribution, occurring all over the North American Continent, throughout Europe, in Australia, and quite probably in various other countries from which it has not been specifically reported.

2. While it has a distinct seasonal prevalence, it is not strictly limited in the season of its occurrence. The great majority of sporadic cases and practically all epidemics in the North Temperate Zone occur in the late summer and fall months, but cases do occur, in this latitude, in all months of the year. No well defined set of weather conditions can be said to be necessary to the occurrence even of epidemics.

3. Although we refer to poliomyelitis as "epidemic," its incidence in any large population is always small even during epidemics. Occasionally, in a small group of people, a large percentage may be attacked, but considering any large group, as the population of a city, a county or a state, the attack-rate, even in so-called epidemics is seldom more than one per thousand, usually even less.

4. As regards its incidence in various classes of the population, poliomyelitis occurs with approximately the same relative frequency among those living under the best of sanitary and hygienic conditions as among those living in the most squalid environment. It is a disease not closely associated with so-called unsanitary or squalid conditions of living. It is, indeed, a very general rule, both in this and other countries, that epidemics have been more intense and more virulent in thinly-settled rural and village communities where living conditions are fairly good than in the overcrowded slums of great cities.

5. In one respect, however, poliomyelitis is strikingly selective in its attack-rate upon a population, namely in that the vast majority of its victims are young children, from fifty to eighty per cent being under six years of age. Adults, though not exempt, are rarely attacked except during intense epidemics, where a relatively large part of the whole population is attacked. It would appear that among adults males are more frequently attacked than females.

6. Epidemics apparently spread with great rapidity or else occur independently over wide areas of country at about the same time. The New York epidemic of 1907 was accompanied, or rather followed by an outbreak in New England, reaching its maximum about a month later than in New York. Records of the epidemic of 1910 in Iowa show a fairly uniform radial spread from a primary focus in the north-central part

of the state to more distant parts. For example, there was a small epidemic in Hancock county in April and May. A considerable epidemic occurred in Mason City, in the adjoining county (Cerro Gordo), beginning in May and declining in August. In the county around Mason City the outbreak reached its maximum in September. In Grundy county, not far from Mason City, an epidemic occurred in August and September; and finally in Sioux, Woodberry and Plymouth counties, in the extreme west of the state, there was an epidemic in September, October and November.

7. As regards the epidemiologic evidence of contagiousness, it has usually been impossible, even in epidemics, to trace lines of contact from case to case. While some small epidemics have, indeed, shown all the characteristics of contagious disease, and while it is possible in almost every closely studied outbreak to find instances of apparent contact-infection rather more often than could be accounted for by coincidence, it is characteristic that the cases are scattered, occurring in persons who have never been in any sort of direct or known indirect contact with a previous recognized case. Not infrequently the patient is a child living far away from the nearest known previous case, and who has certainly not been away from home within a period of several weeks before the attack. Still more striking evidence of the non-contagiousness of poliomyelitis is afforded by the fact that one rarely finds more than a single case in a family, and still more rarely finds multiple cases in a family separated by such an interval as would suggest the infection of one from the other. Numerous instances can be cited where large numbers of children have been exposed in schools or institutions, to acute cases of poliomyelitis without the development of any secondary cases.

On the whole it may be confidently asserted that infection in the majority of cases of poliomyelitis can not be ascribed to direct contact with any previous recognized paralytic case, or any recognizable abortive case of the disease. Indeed, the fact that poliomyelitis occurs most commonly in young children, the very class least exposed to contact with people outside their own family, is, of itself almost sufficient to exclude direct contact as a necessary or even highly important factor in the infection.

Taking a broad view of an outbreak of poliomyelitis such as has occurred in many of our states within the last three years, we have the picture of an infection becoming, within a very short time, disseminated over a wide area of country, attacking, however, only a very small percentage of the population of this area, attacking chiefly children under five years of age.

These points I may reiterate: the rapid spread over a wide area, as the whole of a large city or even a state; the rare incidence of the disease within that area, seldom as much as one case per thousand inhabitants; and finally, the enormously disproportionate incidence among children.

To account for this picture we must assume either an infective agent so distributed as to reach only one out of several thousand inhabitants, and reaching children much more commonly than adults; or we must assume an infection quite generally disseminated throughout the population of this area, but only rarely finding an individual in whom it can produce characteristic morbid effects. Granting an almost uniform and universal susceptibility to infection, then the incidence of the disease must be approximately coincident with the distribution of the specific causative agent.

Several hypotheses have been advanced to explain the irregular distribution of poliomyelitis, and in the present state of our knowledge, each of these deserves careful consideration.

It has been suggested that the lower animals are the chief reservoirs of infection, which is spread from them to man. Again it has been suggested that the dust of streets and barnyards is the chief source or vehicle of infection, and finally the suggestion has been repeatedly made that some insect is a necessary factor in the transmission of poliomyelitis. Each of these hypotheses has, in its support, certain facts which cannot be discussed within this space. None of them, however, adequately explains the rare incidence of the infection, the scattering of cases and the disproportionate incidence in children, without the additional assumption that the majority of persons are not susceptible to the infection. Whether the source of infection is the soil, domestic animals or man; whether the infective agent is spread from its source by dust, by insects, by domestic animals or by human carriers, speaking broadly it will be spread radially, so that as a very general rule those nearest the source will be most exposed to the infection. The grouping of cases in the immediate vicinity of the source of infection is especially striking in the epidemic diseases which we know to be transmitted from animals, or to be conveyed by insects, as, for example, in glanders, in plague, in yellow fever and in typhus fever. Again, none of our epidemic diseases known to be derived largely from domestic animals or transmitted by insects is distinctively a children's disease. There is good reason to believe that adults are proportionately quite as much exposed to infection from these sources as are children.

Therefore, in order to make any of the above hypotheses competent to explain the epidemiology of poliomyelitis, we must couple with it the assumption that susceptibility to the infection is relatively rare, and that children are more susceptible than adults. In short, no hypothesis yet advanced is sufficient to account for certain characteristics of poliomyelitis, namely, its wide distribution, small total incidence and preponderance in children, unless coupled with the assumption of a large factor of variations in individual susceptibility.

On the other hand, granting, as appears necessary whatever the vehicle

or source of infection, that the peculiar incidence of the disease is dependent largely upon variations in individual susceptibility, then its spread by personal contact is readily explainable, in harmony with the facts shown experimentally and closely analogous to what is known of other diseases whose epidemiology has been more thoroughly worked out.

Cerebro-spinal meningitis furnishes an excellent example of a disease which we now feel reasonably assured is disseminated by personal contact, but in which lines of direct contact are no more traceable than in poliomyelitis. It is only by laboratory methods that the mystery of the spread of epidemic cerebro-spinal meningitis has been solved. In recent years it has been demonstrated that a large number of the persons in communities where this disease is epidemic, harbor the meningococci in their naso-pharynx, without developing symptoms of meningitis; in other words, the infective agent of cerebro-spinal meningitis is apparently very widespread during epidemics, but the incidence of the disease is limited by the insusceptibility of the majority of people. The demonstration of meningococcus "carriers" serves, in this instance, to prove that susceptibility to the infection is relatively rare. In poliomyelitis, carriers have not yet been demonstrated,* but the epidemiological characteristics are those which we should expect of a carrier-borne disease. And it is these general characteristics, rather than individual instances of apparent infection by indirect contact, that lend probability to the idea of "carriers" forming the missing links in the spread of the disease by contact.

The two diseases are analogous in their constant endemic occurrence in sporadic form and their occasional occurrence in epidemics, which are characteristically of irregular distribution. They are further analogous in their comparatively small incidence in the total population, their preponderating incidence in childhood, the scattering of cases with no obvious lines of contact, and in the fact that each has a distinct though not absolutely limited seasonal prevalence.

To recapitulate, it is not the object of this paper to deduce a definite conclusion as to the means by which poliomyelitis is disseminated in nature. The facts do not appear as yet to warrant a final conclusion. It has been intended, however, to point out that of the hypotheses which have been so far advanced none is capable of explaining the epidemiologic facts without ascribing to individual variations in susceptibility a very important role in determining the incidence of the infection. Granting this, and taking into consideration the laboratory evidence of the contagiousness of poliomyelitis, the most probable hypothesis would appear to be that the disease is transmissible by contact,—by transfer of infectious discharges from person to person,—the lines of contact being ob-

*See note at conclusion.

scured by the interposition between recognized cases of insusceptible persons who become "carriers."

As to what constitutes susceptibility we are as yet ignorant. Epidemiologic studies should aim to collect data on this point by more intensive studies of the persons affected. If we can ascertain the conditions which determine susceptibility and immunity to this infection, it may be that we will be able to accomplish something in the way of prevention. If not, it must be admitted that the idea of transmission above suggested carries with it a rather pessimistic outlook as to the possibility of prevention.

AUTHOR'S NOTE.—Since this paper was presented several highly important contributions have been made to our knowledge of experimental poliomyelitis. Kling, Wernstedt and Petterson, who had previously shown the infectiousness for monkeys of the naso-pharyngeal, tracheal and intestinal secretions of persons acutely ill with poliomyelitis have more recently announced that they have been able to demonstrate the virus in the buccal and intestinal secretions of well persons who had been closely associated with paralytic cases of poliomyelitis. In the monkeys infected in this way they were, however, unable to demonstrate the infiltrative lesions of the cord which have been considered characteristic of poliomyelitis. More recently Flexner, Clark and Fraser have demonstrated, beyond a question, the presence of the poliomyelitic virus in the naso-pharyngeal discharges of two apparently healthy adults closely associated with a case of poliomyelitis. Thus experimental proof has been adduced of the occurrence, in passive human carriers, of the virus of poliomyelitis.

Rosenau and Brues have shown that poliomyelitis may be experimentally transmitted from monkey to monkey by the bites of *Stomoxys calcitrans*, and their observations have been confirmed by Anderson and Frost.

Finally, Flexner and Noguchi have succeeded in cultivating in vitro the virus of poliomyelitis.

The additional evidence brought forward since this paper was prepared, while demanding a more careful consideration of biting insects, especially *Stomoxys calcitrans*, as possible agencies in the natural transmission of poliomyelitis, does not appear to the writer to necessitate any material change in the general conclusions above given.